



# **Armed Forces College of Medicine AFCM**



# **Histological structure of Capillaries, veins and lymph vessels**

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# INTENDED LEARNING OBJECTIVES (ILO)



## **By the end of this lecture the student will be able to:**

1. Describe the histological structure of the capillaries, medium-sized artery, medium-sized vein, inferior vena cava and lymph vessels.
2. Correlate the histological structure of capillaries, medium-sized artery, medium-sized vein, inferior vena cava and lymph vessels to their functions.
3. Correlate the histological structure of lymph vessels to their functions.
4. Interpret the altered microscopic structure of capillaries and veins in different diseases.

## Key points of this lecture



- 1- Histological structure of Continuous, fenestrated and sinusoidal capillaries and their clinical correlation.
- 2- Histological structure of venules.
- 3- Histological structure of medium-sized veins and their clinical correlation.
- 4- Histological structure of large veins.
- 5- Histological structure of the lymphatic vessels.

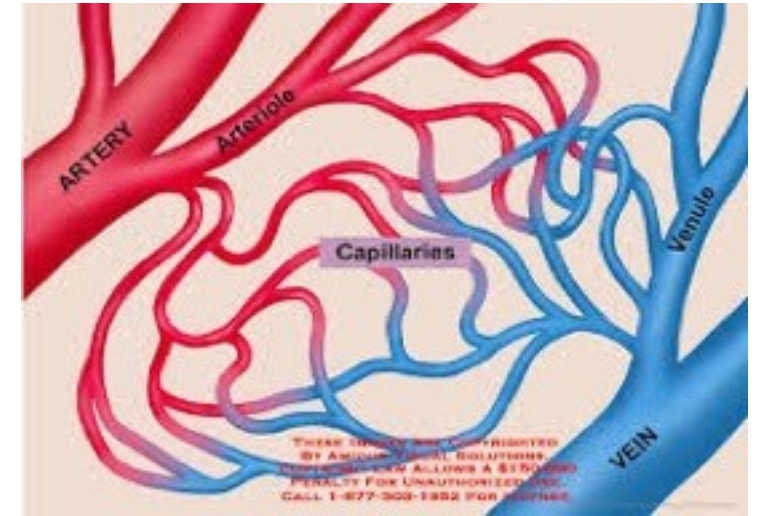
# Blood capillaries



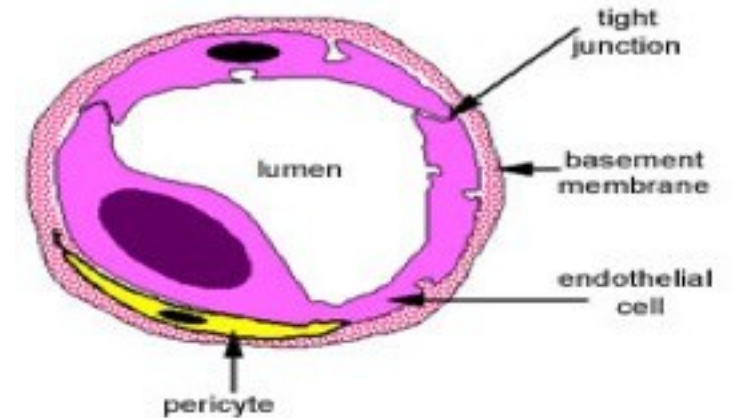
- These are thin walled vessels connecting arteries to veins.
- They branch and anastomose forming capillary beds
- Lumen diameter is 4-10  $\mu\text{m}$ .

## Structure:

- Formed of a single layer of squamous cells resting on basal lamina.
- Surrounded by **Pericytes**
- The basal lamina of both cells (endothelium & pericytes) are fused



<https://qph.fs.quoracdn.net/main-qimg-93c44f6234a7ed034801af6198453556-c>



<https://i.pinimg.com/originals/96/0c/2e/960c2e7679feb8f00cbca90c163f6f14.jpg>

# Types of capillaries

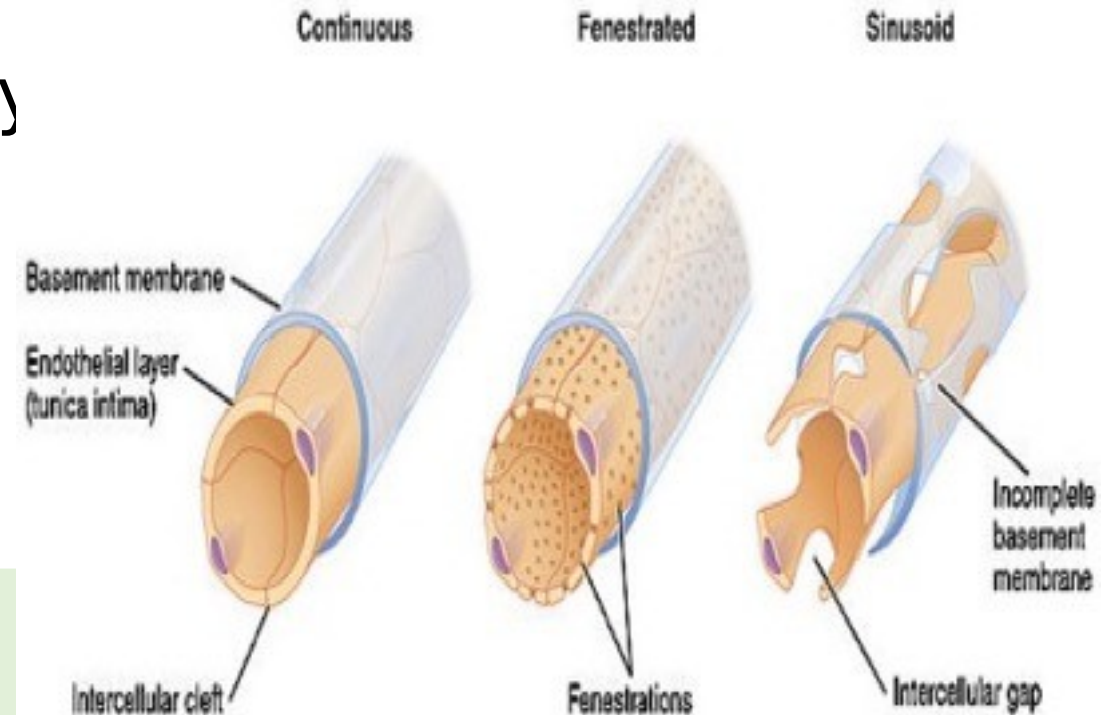


Capillaries are classified into three types

## 1- Continuous Capillaries

## 2- Fenestrated Capillaries

## 3- Sinusoidal (discontinuous) Capillaries



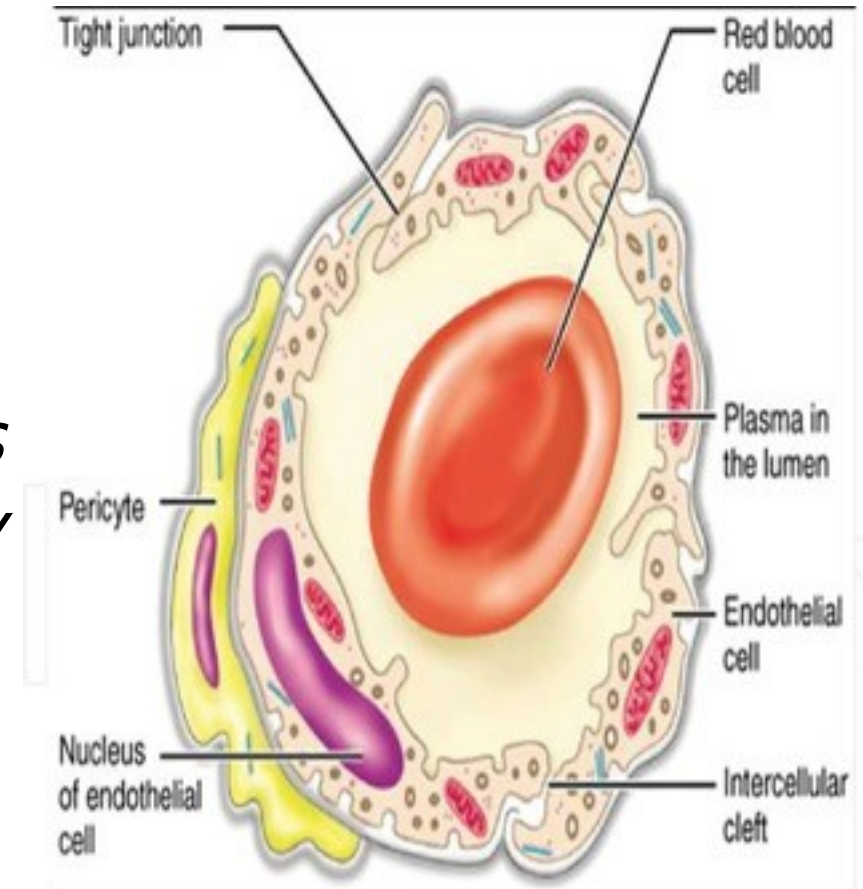
<http://www.assignmentpoint.com/wp-content/uploads/2017/07/Capillary-0.jpg>

# Continuous capillaries



**-Site:** Muscles, nervous tissue, c.t., lung, and exocrine glands.

- The most common type.
- *Continuous endothelium + continuous basement membrane. (surrounded by pericyte).*
- The endothelial cells are connected together by tight junction.
- Numerous vesicles indicating transcytosis of macromolecules in both



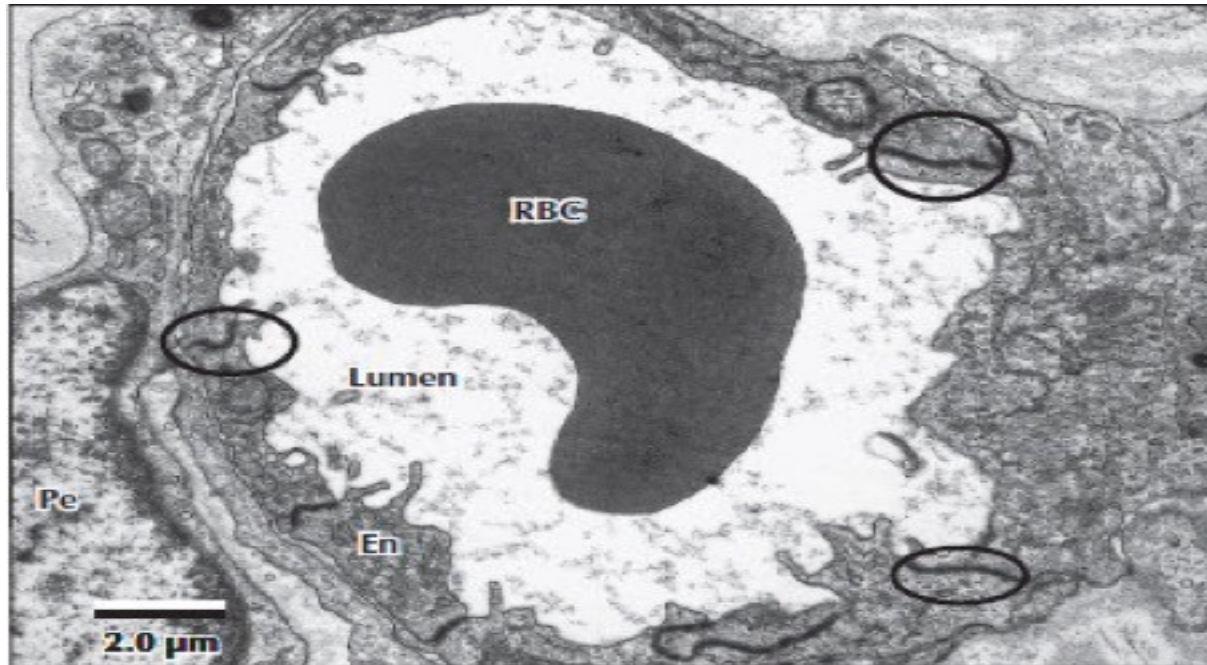
<https://ai2-s2-public.s3.amazonaws.com/figures/2017-08-08/38c41a5914ccaabe5e79ab85633687f818167abe/4-Figure3-1.png>



# Functions:



- Prevent passage of molecules between cells.
- Passage of wanted molecules occurs through the endothelium occurs by transcytosis (via pinocytotic vesicles)



<https://d1yboe6750e2cu.cloudfront.net/i/3e227c6030e29c49f1a3b5e5bca71872b4917e23>



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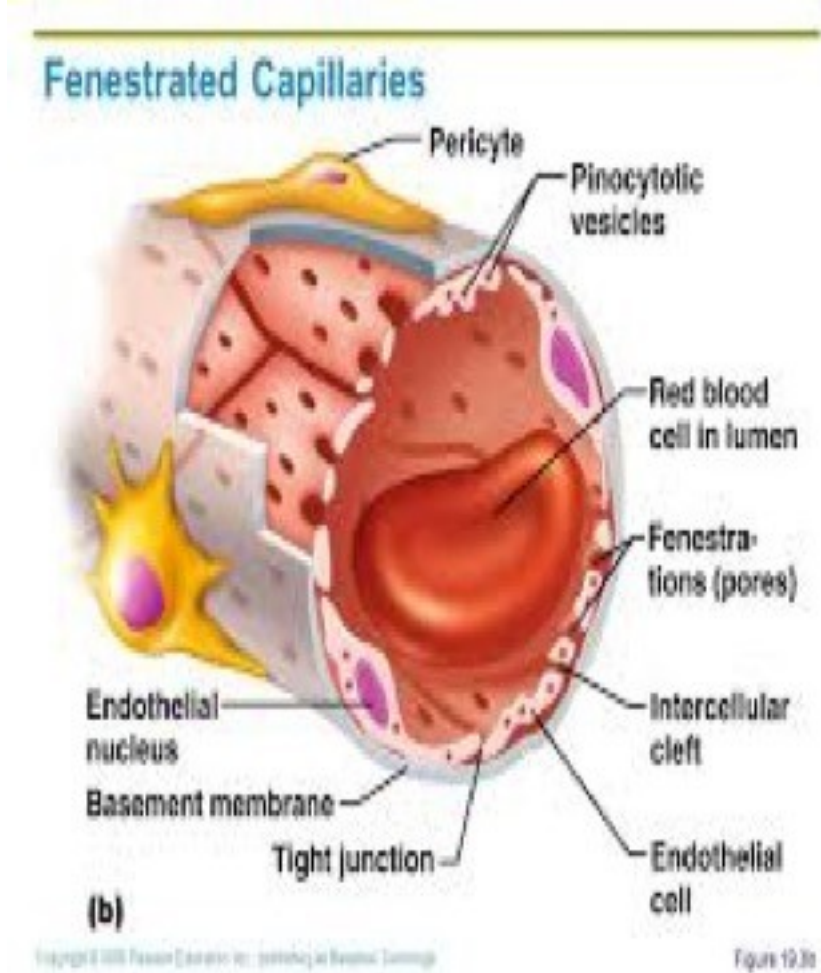
# Fenestrated capillaries

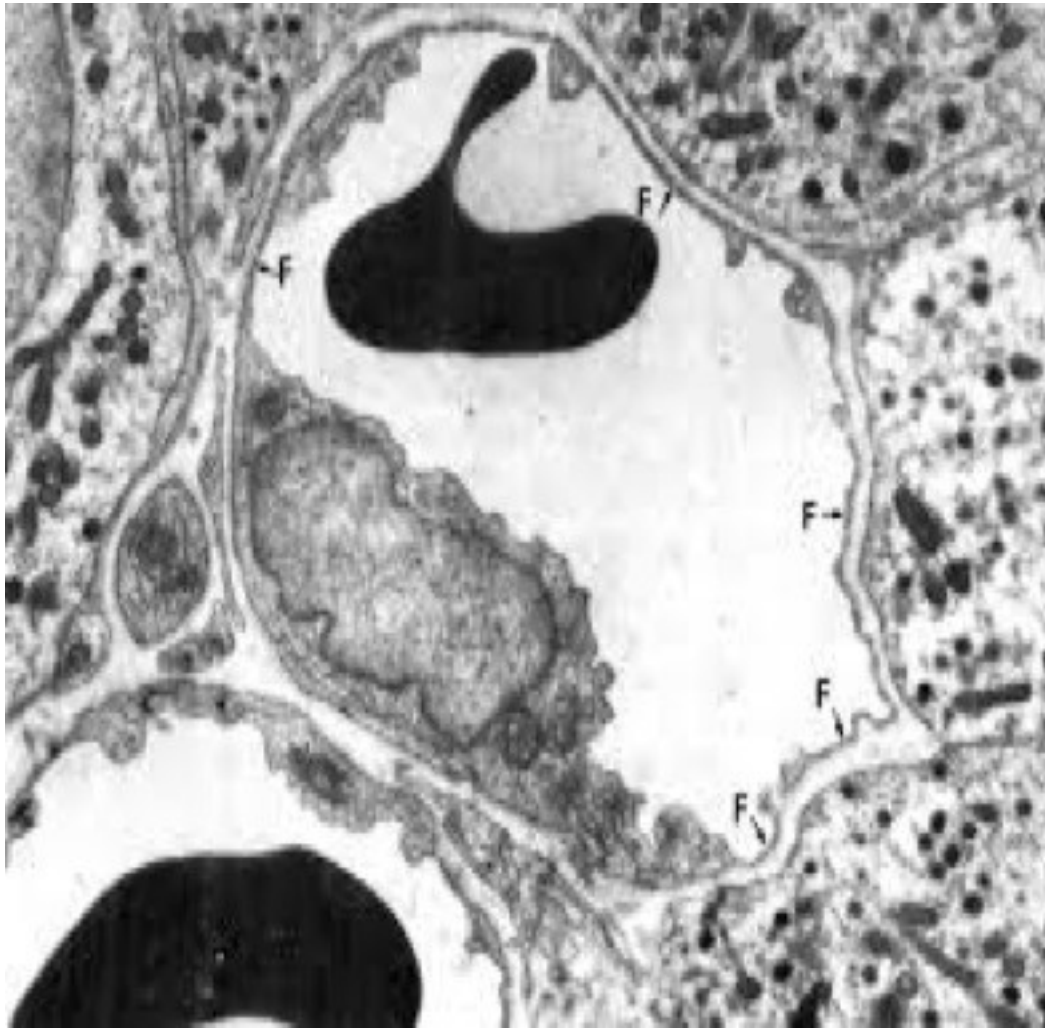


**Site:** Areas of fluid transport (i.e. intestine and renal glomeruli)

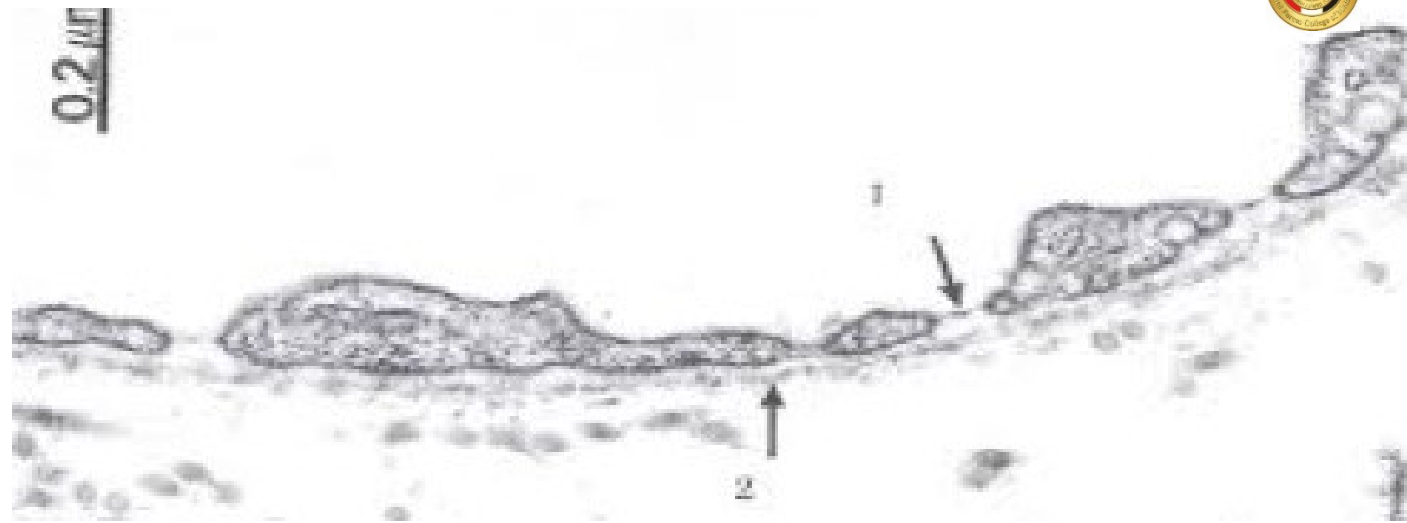
**Structure:**

- *Perforated endothelium + continuous basement membrane. (surrounded by pericyte).*
- The endothelial cells are joined at their ends by tight junctions
- There are minute, circular transcellular openings (fenestrae) that perforate





[https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQOIN-ej8nDXPz\\_-04FRti4tGRWdDQfr-eyakd3UokEXBZjmK3j](https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcQOIN-ej8nDXPz_-04FRti4tGRWdDQfr-eyakd3UokEXBZjmK3j)



<https://www1.udel.edu/biology/Wags/histopage/empage/ebv/ebv4.gif>

- **Fenestrae are either:**
  - Covered **with diaphragm** (in intestine)
  - **Not covered with diaphragm** (in renal glomeruli).
- These **sieve-like** structures allow more extensive molecular exchange across the endothelium.

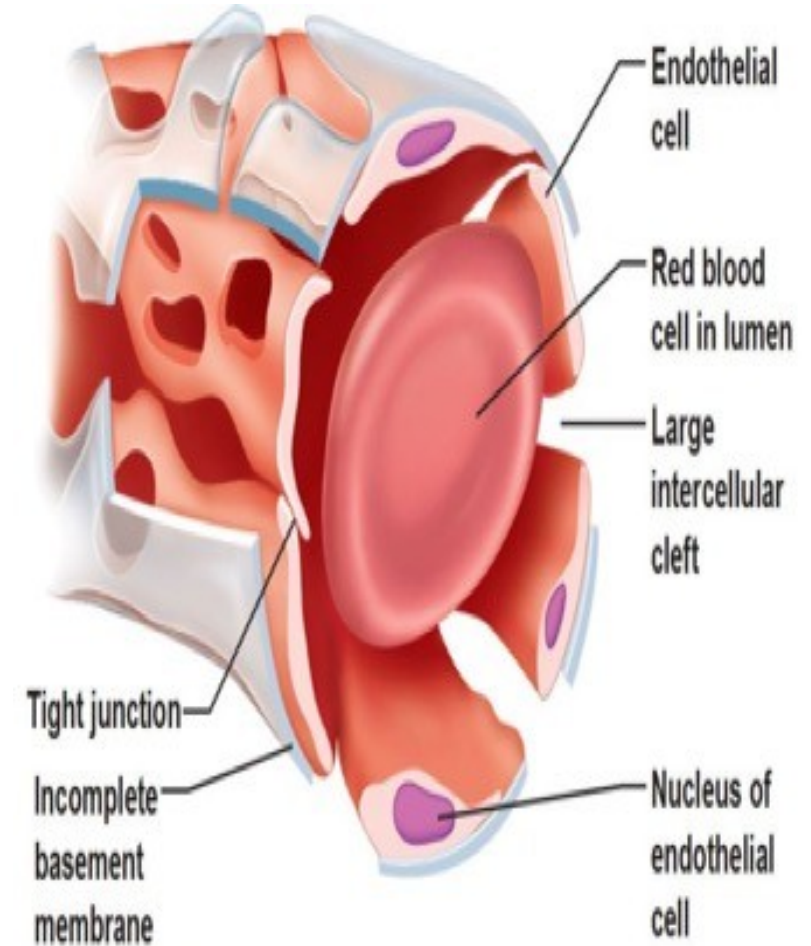
# Blood sinusoids



**Sites:** bone marrow, spleen, liver, and pituitary.

**Structure:**

- *Discontinuous endothelium* + *discontinuous basement membrane.*
- Irregular wide lumen up to 20  $\mu\text{m}$ .
- Endothelial cells are separated by wide gaps.
- Basal lamina is either absent or incomplete.



<https://i.pinimg.com/originals/70/b5/dc/70b5dcec26ff136eac65f042f845953.jpg>

# Functions of capillaries



## **Exchange of gases and metabolites between blood and tissues through:**

- Diffusion (small molecules)
- Pinocytosis, fenestrae and intercellular gaps (large molecules)

# Clinical correlation



## Diabetic microangiopathy

- The **hyperglycemia** or excessive blood sugar that occurs with diabetes

Diffuse thickening of capillary basal laminae

Decrease in metabolic exchange at these vessels

Occurs particularly in the kidneys, retina, skeletal muscle, and skin.



# QUIZ



Identify the type of this blood vessel

Identify the cell marked by the arrow



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Cardiopulmonary Module



# Veins

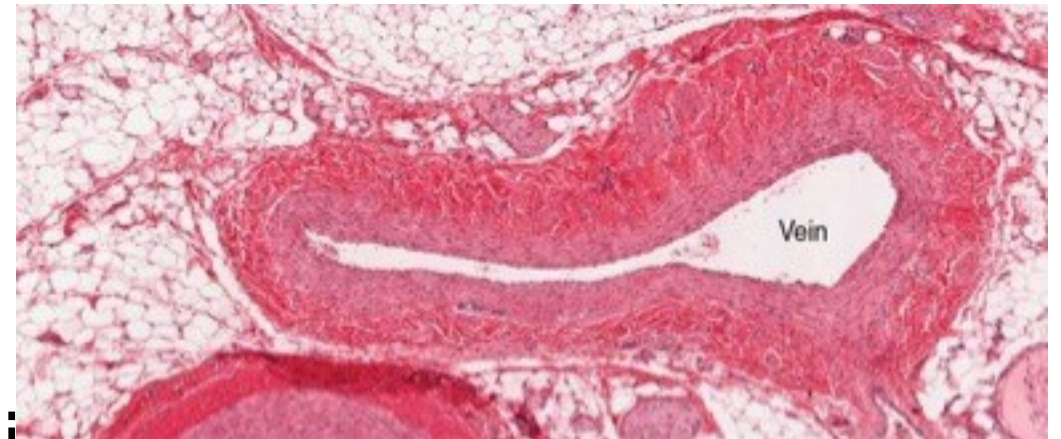


## General structure:

- Have wide collapsed lumen, and relatively thin wall
- No elastic fibers (only few in largest veins).
- T. adventitia is the most prominent thick layer.

## - Veins are classified into:

- Venules: - Post capillary venules  
- Muscular venules
- Medium-sized veins (muscular veins)
- Large veins.



<https://i.pinimg.com/originals/35/35/7e/35357ec6dae0d69678b8773175c249ba.jpg>

# Venules

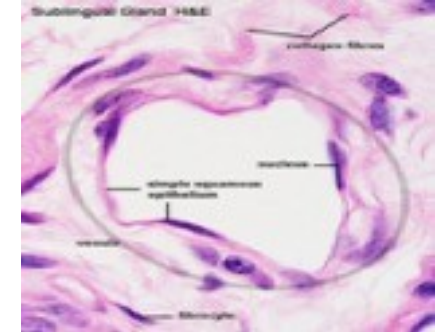


## ❖ Post capillary venules:

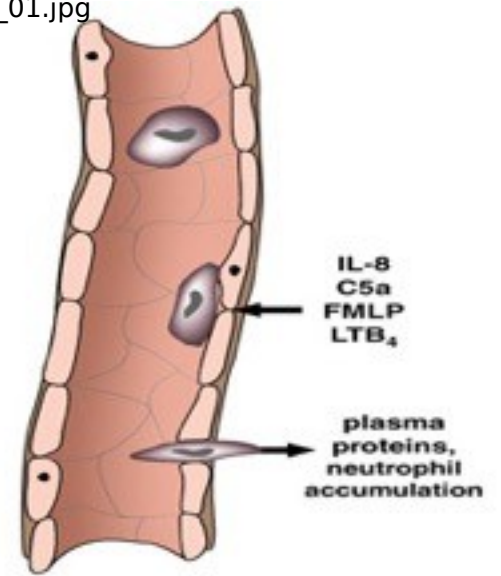
- Lumen diameter up to  $20\mu\text{m}$  (larger than capillaries).
- Their walls are similar to capillaries (endothelium surrounded by pericytes).

- **Function:** site of exchange of blood cells and tissue exudate between circulation and tissues

## ❖ Muscular venules: Large venules with recognizable tunica media.



[https://embryology.med.unsw.edu.au/embryology/images/7/78/Vein\\_histology\\_01.jpg](https://embryology.med.unsw.edu.au/embryology/images/7/78/Vein_histology_01.jpg)



Post-capillary Venule

<http://virtualpharmacologylab.com/resources/assets/IP/jpg/ven3b.jpg>

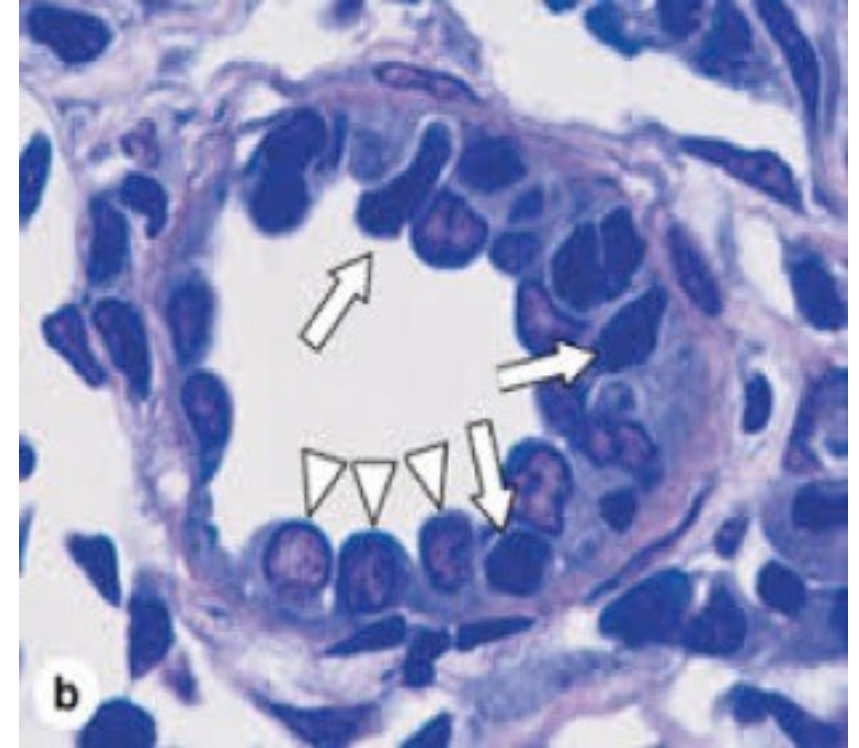


## High endothelial

**venules:** - These are special type of post capillary venules, present in all lymphoid organs **except the spleen.**

- Lined by simple cuboidal epithelium instead of simple squamous.

- Have receptors on their luminal surfaces for lymphocytic migration into specific regions of lymphoid organs.



<http://histonano.com/books/Junqueira%27s%20Basic%20Histology%20PDF%20WHOLE%20BOOK/14.%20The%20Immune%20System%20&%20Lymphoid%20Organs.htm>

# Medium-sized veins



**Examples;** femoral, ulnar, radial, .....

**Structure:** their walls are formed of the usual three

## T. Intima:

**A- Endothelium:** simple squamous.

**B- Subendothelial C.T.**

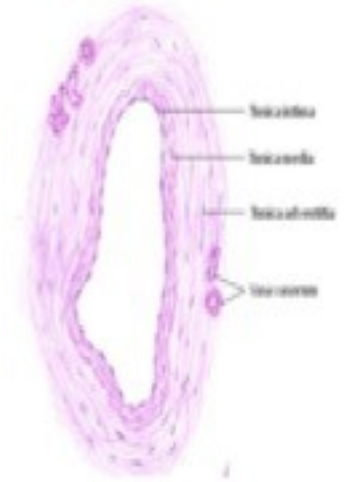
**C- NO EEL**

## T. Media:

-Contains few layers of **smooth muscle cells**.

-Few reticular fibers.

- NO EEL



<https://3.bp.blogspot.com/-DLkYqcmZeQE/XMCTOVnk2QI/AAAAAAAAAFbE/XBIMrAf5Ao4slaVVSggnuS9zL0R6UFNR4QCLcBGAS/s1600/Slide1.JPG>

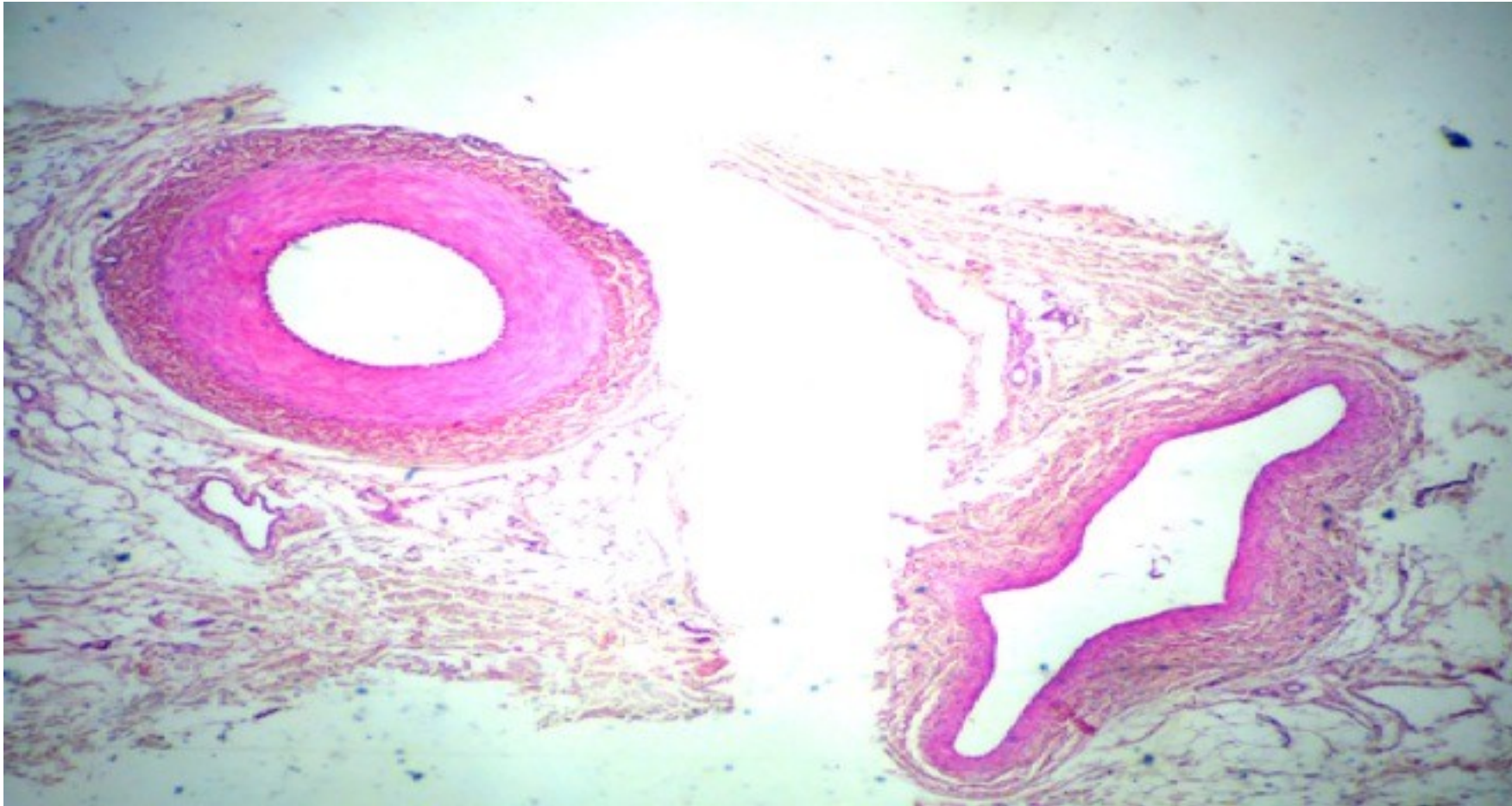
## T. Adventitia:

- The **thickest** coat.

- Rich in collagen fibers.

- Contains numerous vasa vasorum and nerves and lymphatics





Mohamed AS et al., Practical histology for first year medical students 1<sup>st</sup> edit., 2010

# Large veins



- Veins with a diameter more than 10 mm.
- Example: inferior vena cava (IVC) and superior vena cava (SVC).
- **Structure:** their walls are formed of three layers

## **T. Intima:**

**A-**  
**Endothelium:**  
simple  
squamous.

**B-**  
**Subendothelial  
CT**

New Five Year Program

## **T. Media:**

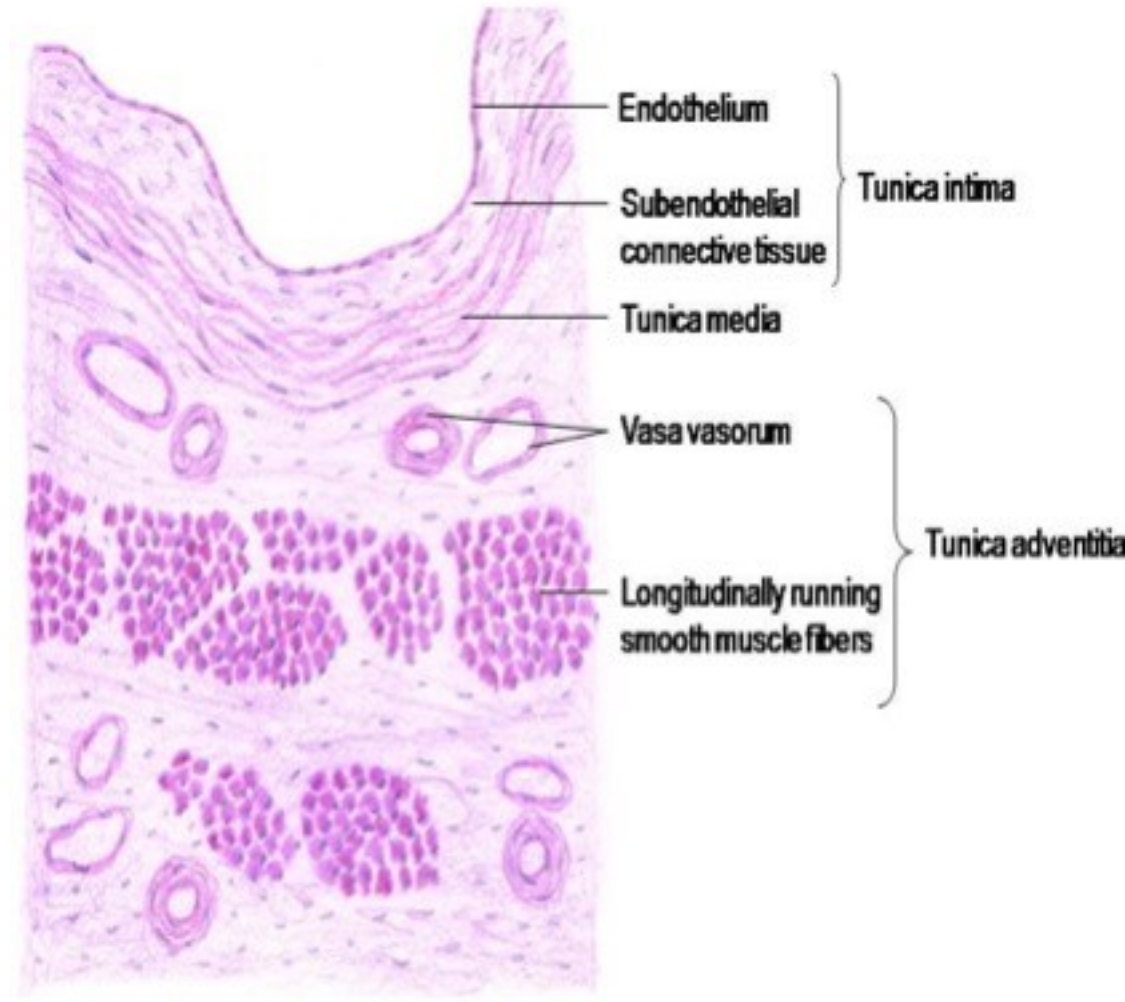
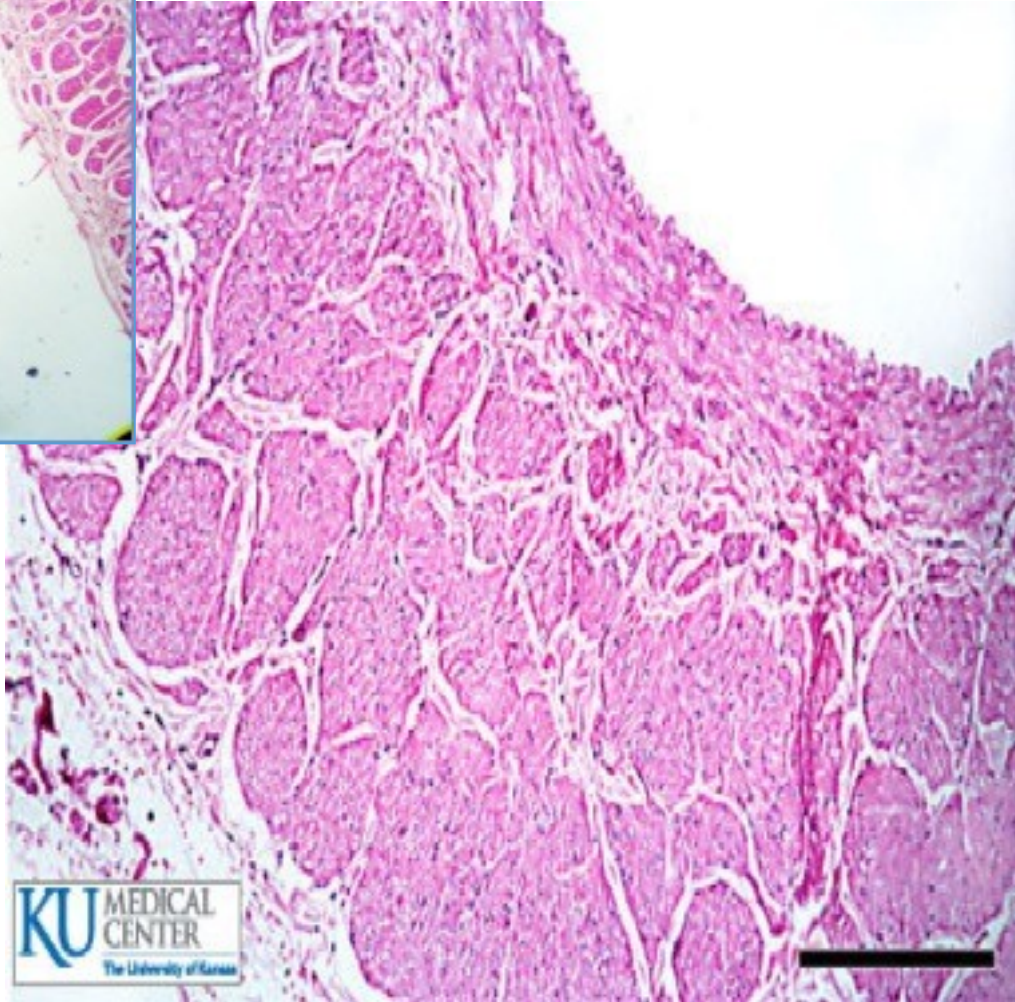
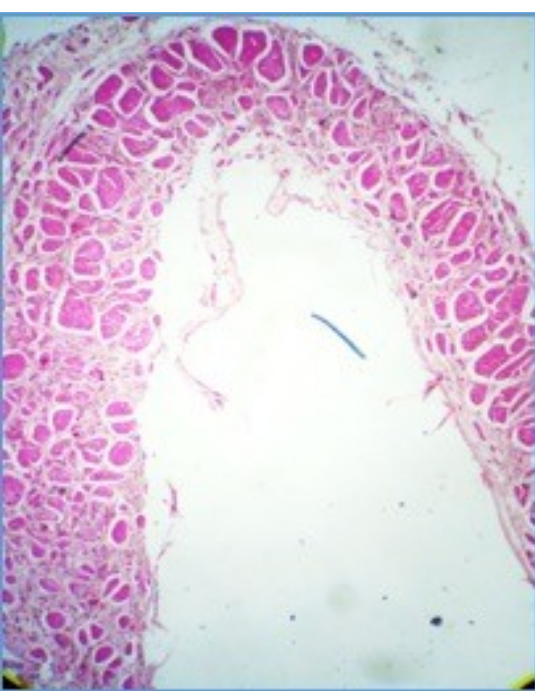
- Thin and contains few layers of **smooth muscle cells**.
- c.t.
- **NO EEL**

Cardiopulmonary Module

## **T. Adventitia:**

- The thickest coat.
- It contains abundant collagen fibers and few elastic fibers.
- Contains **longitudinal smooth muscle bundles**
- Contains **numerous vasa vasorum** and

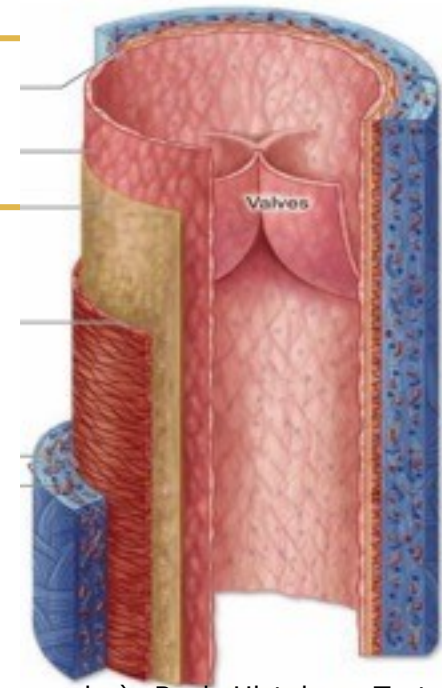




Mohamed AS et al.,  
Practical histology for  
first year medical  
students 1<sup>st</sup> edit., 2010

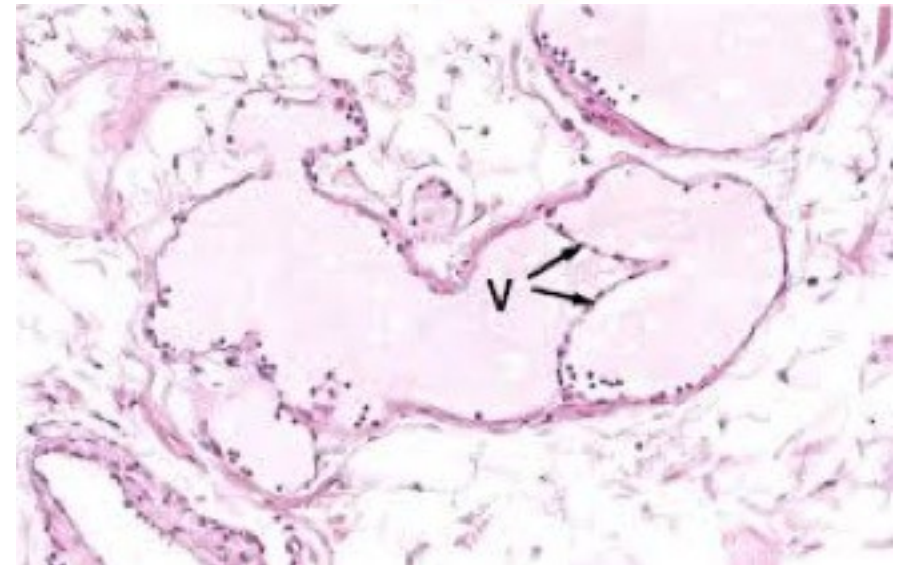
<https://www.kumc.edu/instruction/medicine/anatomy/histoweb/vascular/vasc03.htm>  
[https://1.bp.blogspot.com/NiLeQwK\\_aCw/Vr11o0rJCQI/AAAAAAAAADSY/f8twpHbO8rU/s1600/Slide14.JPG](https://1.bp.blogspot.com/NiLeQwK_aCw/Vr11o0rJCQI/AAAAAAAAADSY/f8twpHbO8rU/s1600/Slide14.JPG)

# Venous valves



Junqueira's Basic Histology; Text and Atlas, 14<sup>th</sup> edition 2016, pp: 221

- These are folds of the tunica intima.
- Formed of a core of CT rich in elastic fibers, covered on both sides with endothelium.
- **Site:** present in medium size veins and large veins.
- **Function:** ensure one way flow of



<https://www.studyblue.com/notes/note/n/lymphatic-histology/deck/4141691>

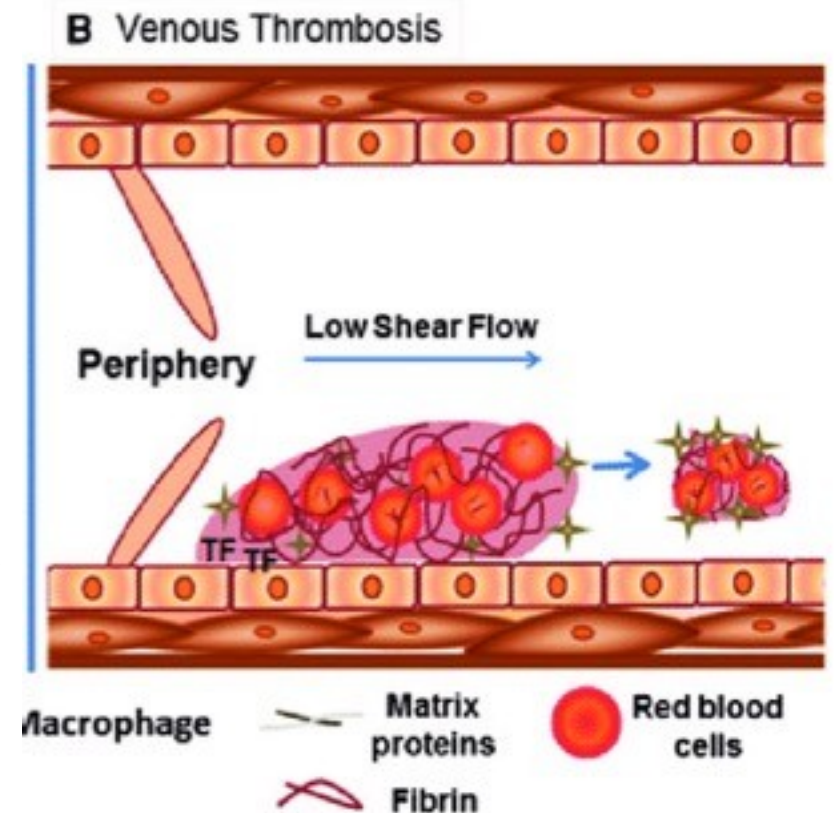


# Clinical correlation



## Deep venous Thrombosis (DVT)

- It is associated with immobilization of the lower limbs due to prolonged bed rest (after surgery or hospitalization), orthopedic casts.
- Fibrous aggregate of platelets and clotting factors occurs, which may occlude the lumen and obstruct blood flow.
- If it **dislodges from the intima** and travels in the bloodstream, embolism develops (life-threatening)



[https://www.researchgate.net/profile/Milka\\_Koupenova-Zamor/publication/311986292/figure/fig1/AS:547843712978944@1507627527353/Major-differences-between-arterial-and-venous-thrombosis-A-Arterial-thrombosis-occurs.png](https://www.researchgate.net/profile/Milka_Koupenova-Zamor/publication/311986292/figure/fig1/AS:547843712978944@1507627527353/Major-differences-between-arterial-and-venous-thrombosis-A-Arterial-thrombosis-occurs.png)

# Lymphatic vessels



## Lymphatic capillary

Irregular, with very thin endothelial cells  
*(No tight junctions and discontinuous basal lamina)*



## Larger lymphatic vessel

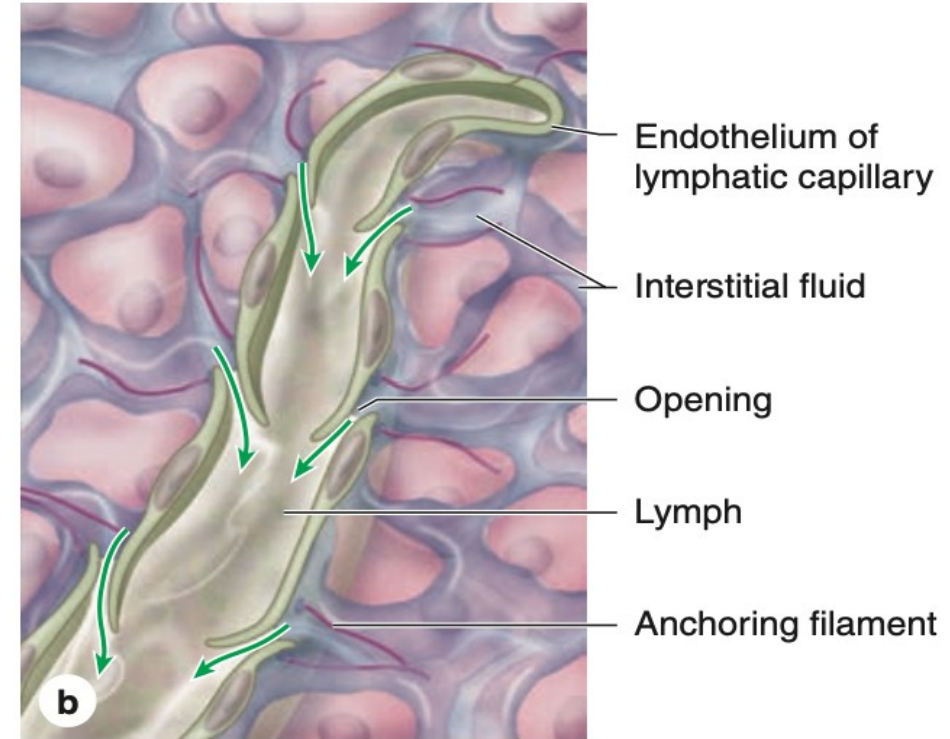
Few smooth muscles, have valves  
*(No tunica media, very thin tunica adventitia)*



They converge into **thoracic duct (left) and right lymphatic duct.**



To **blood circulatory system**



Junqueira's Basic Histology; Text and Atlas. 14<sup>th</sup> edition 2016, pp: 244

## Question 1



**Which layer of Inferior vena cava contains bundles of longitudinal smooth muscle fibers ?**

- A. Tunica intima
- B. Subintimal C.T.
- C. Tunica media
- D. Tunica adventitia

## Question 2



**Which is the commonest type of blood capillaries in the body ?**

- A. Continuous
- B. Fenestrated with diaphragm
- C. Fenestrated without diaphragm
- D. Sinusoidal capillaries



## Question 3



**Which type of blood vessels contains more vasa vasorum?**

- A. Metarterioles
- B. Large veins
- C. Large arteries
- D. Sinusoids

## Question 4



**Which is the thickest layer of medium sized veins?**

- A. Tunica intima
- B. Tunica media
- C. Tunica adventitia
- D. Subendothelial tissue

- **Give reason:**

- 1. Elastic laminae of blood vessels are fenestrated.**

Fenestrations enable substances to diffuse readily through to the deep layers and reach cells deep within the wall of the vessel

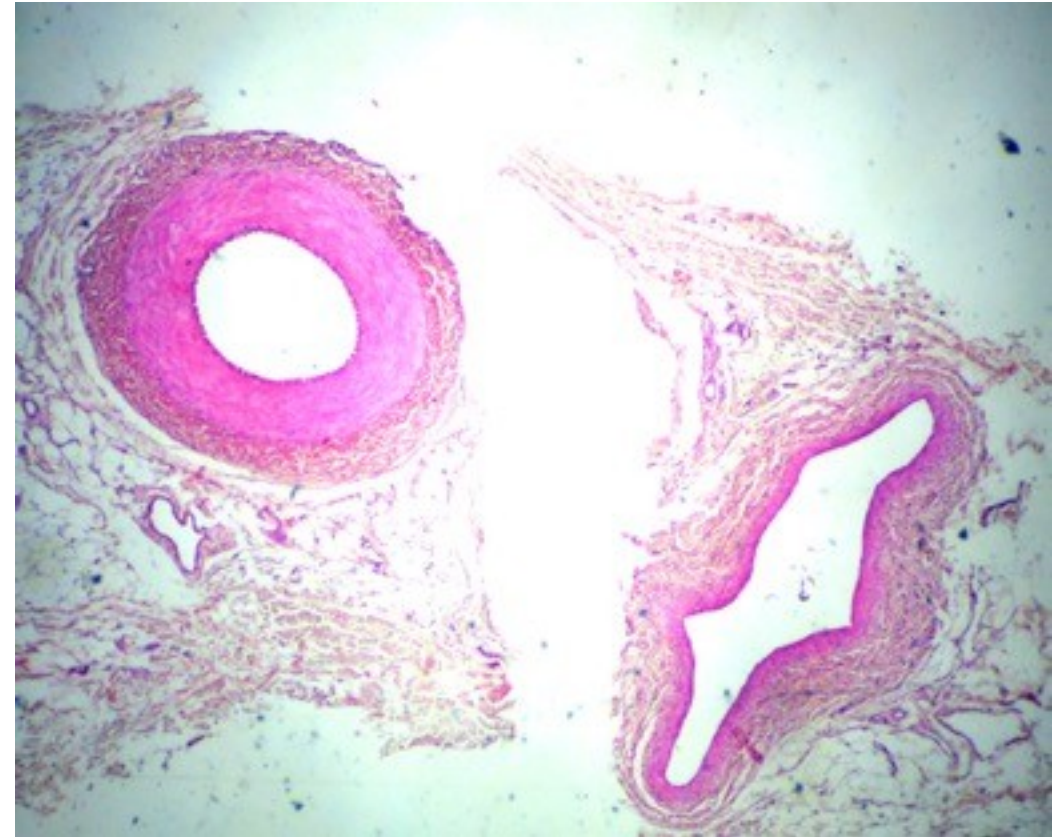
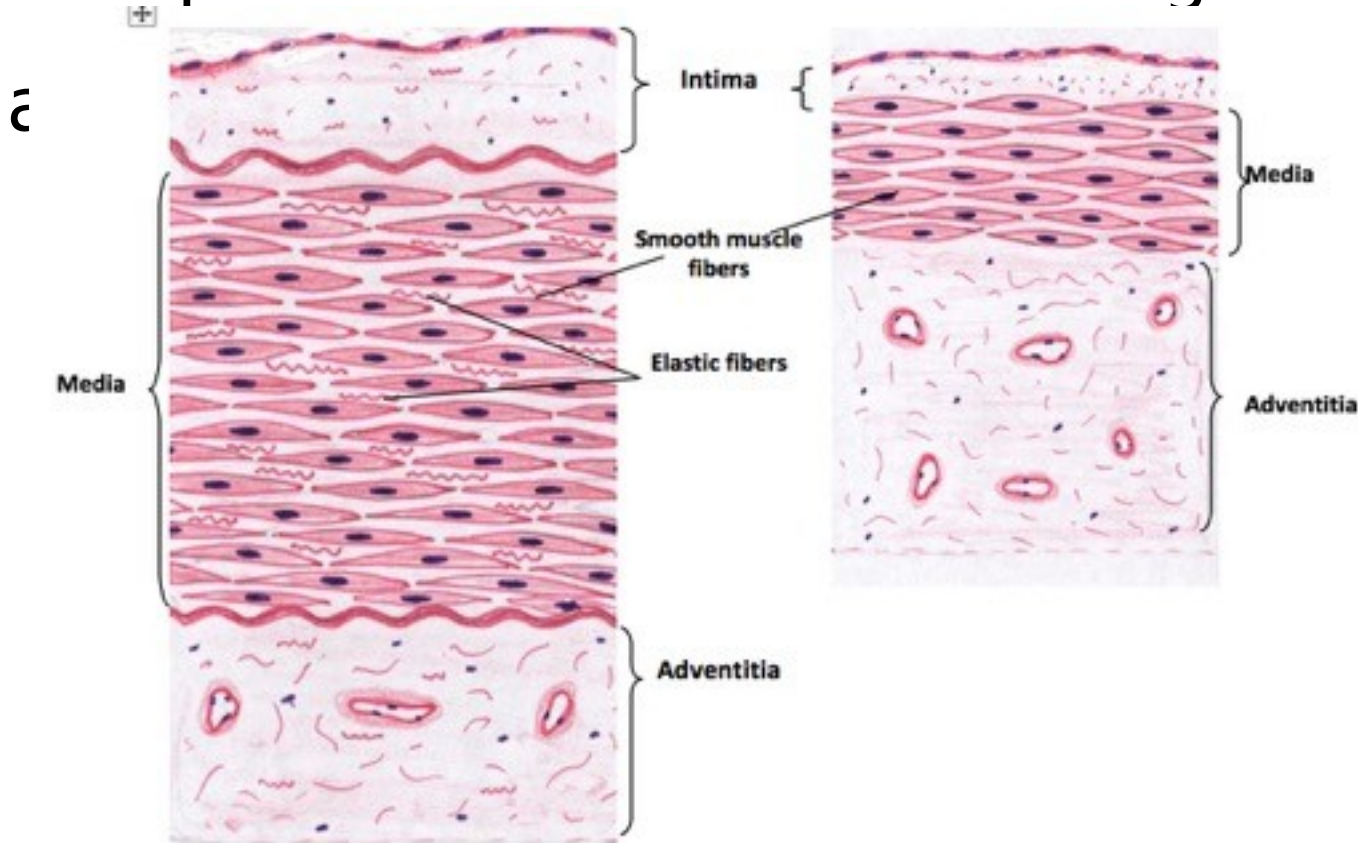
- 2. Presence of vasa vasorum in adventitia of blood vessels.**

Vasa vasorum supplies blood to the vascular walls themselves, especially in the large thick-walled vessels.

# Lecture Quiz



Compare between the histological structure of medium sized



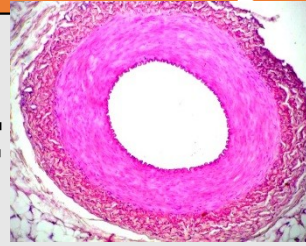
Mohamed AS et al., Practical histology for first year medical students 1<sup>st</sup> edit., 2010

## Medium sized artery

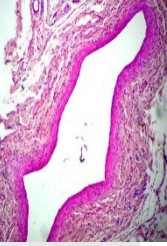
## Medium sized vein

### Wall and lumen

- Narrow patent
- Thick wall



- Wide irregular collapsed lumen
- Thin wall



### Tunica intima

- Thick
- Has well developed internal elastic lamina.

- Thin
- Has no internal elastic lamina.

### Tunica media

- Thick.
- Formed of elastic and smooth muscle fibers.
- External elastic lamina may be present

- Thin.
- Formed of smooth muscle fibers.
- No external elastic lamina.

### Tunica

- **Compare between:**

## **Histological structure of aorta and inferior vena cava**



## Aorta

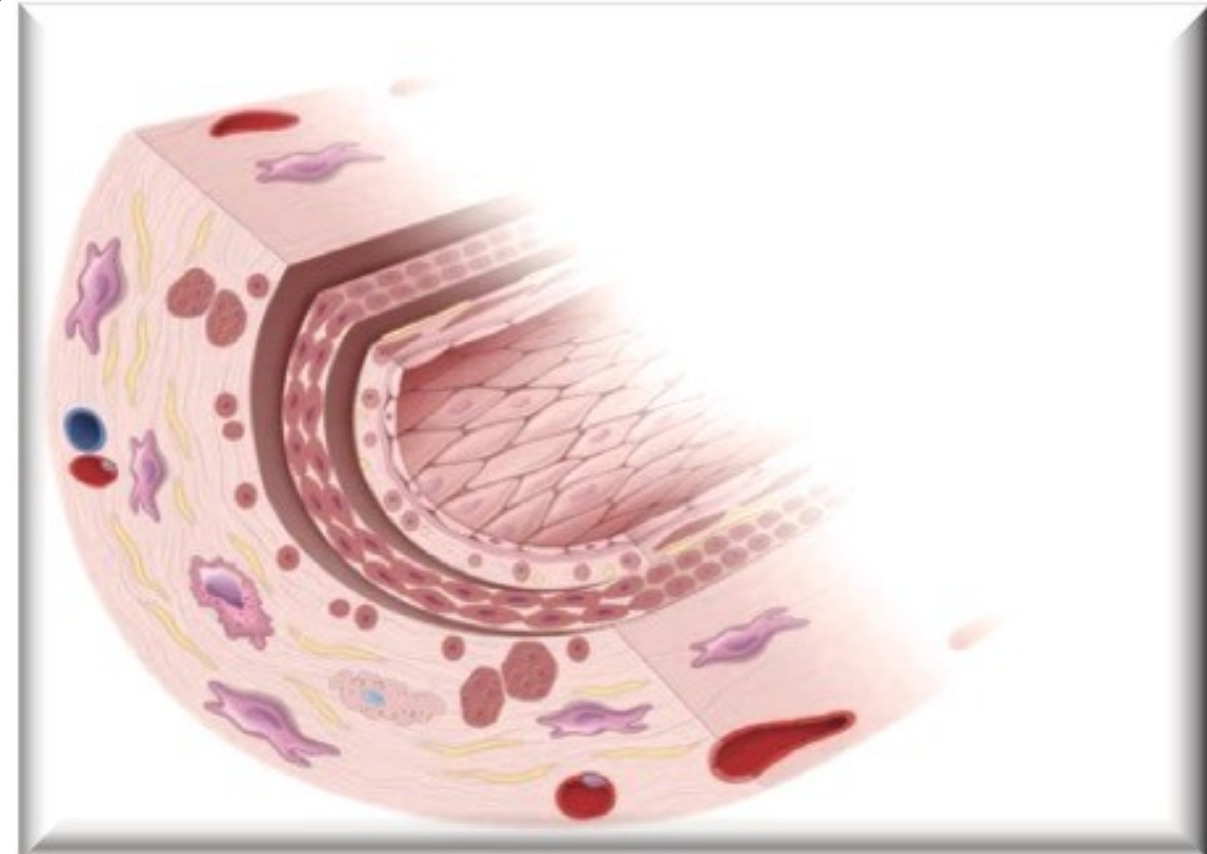
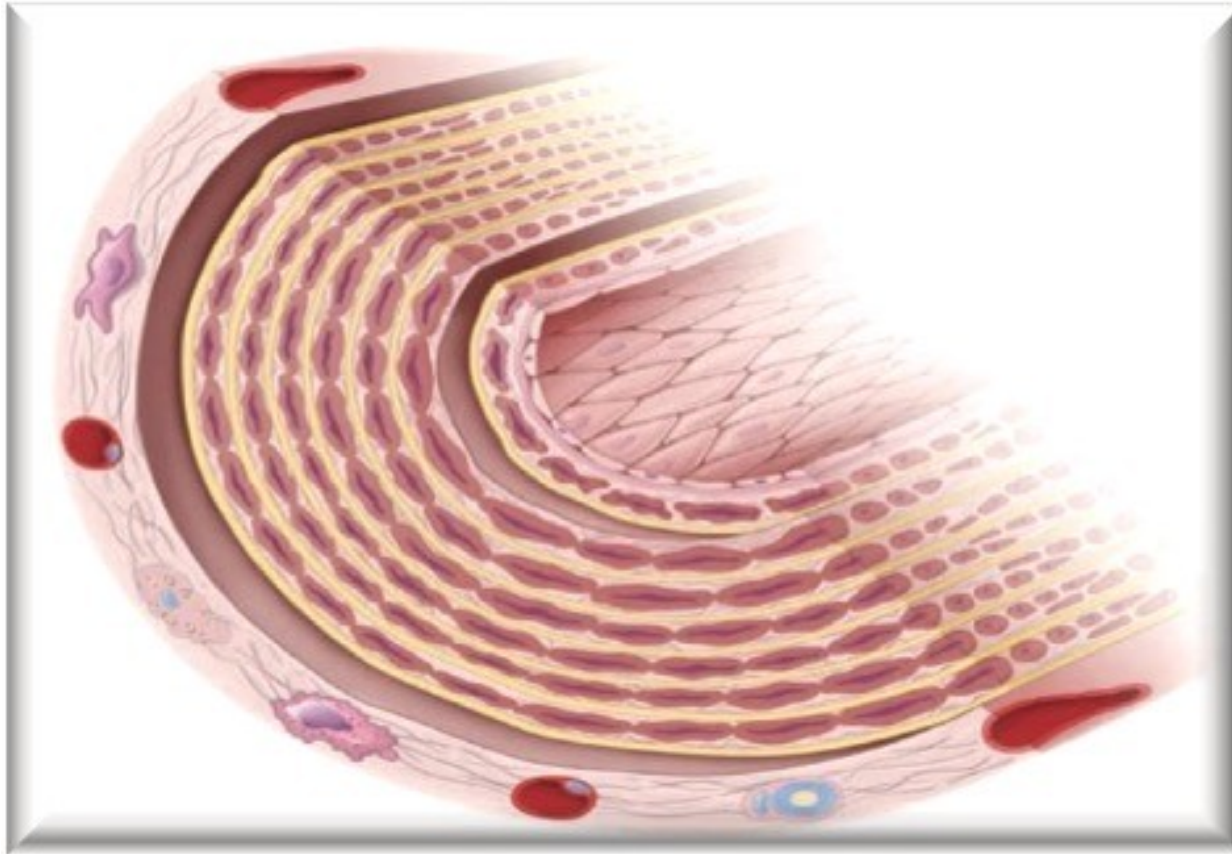
## I.V.C.

Wall and lumen	<ul style="list-style-type: none"> <li>• Wide rounded patent lumen</li> <li>• Thick wall</li> </ul>	<ul style="list-style-type: none"> <li>• Wide irregular collapsed lumen</li> <li>• Thin wall</li> </ul>
Tunica intima	<ul style="list-style-type: none"> <li>• Thick</li> <li>• Has internal elastic lamina but not prominent.</li> </ul>	<ul style="list-style-type: none"> <li>• Thin</li> <li>• Has no internal elastic lamina.</li> </ul>
Tunica media	<ul style="list-style-type: none"> <li>• Thick.</li> <li>• Contain many fenestrated elastic laminae</li> <li>• Smooth muscle fibers.</li> <li>• External elastic lamina is present</li> </ul>	<ul style="list-style-type: none"> <li>• Thin.</li> <li>• No elastic laminae</li> <li>• Few layers of smooth muscle fibers.</li> <li>• No external elastic lamina.</li> </ul>
Tunica adventitia	<ul style="list-style-type: none"> <li>• Thin</li> </ul>	<ul style="list-style-type: none"> <li>• Thick, containing longitudinal bundles of smooth muscle</li> </ul>

# QUIZ



## Identify the type of the following blood vessels

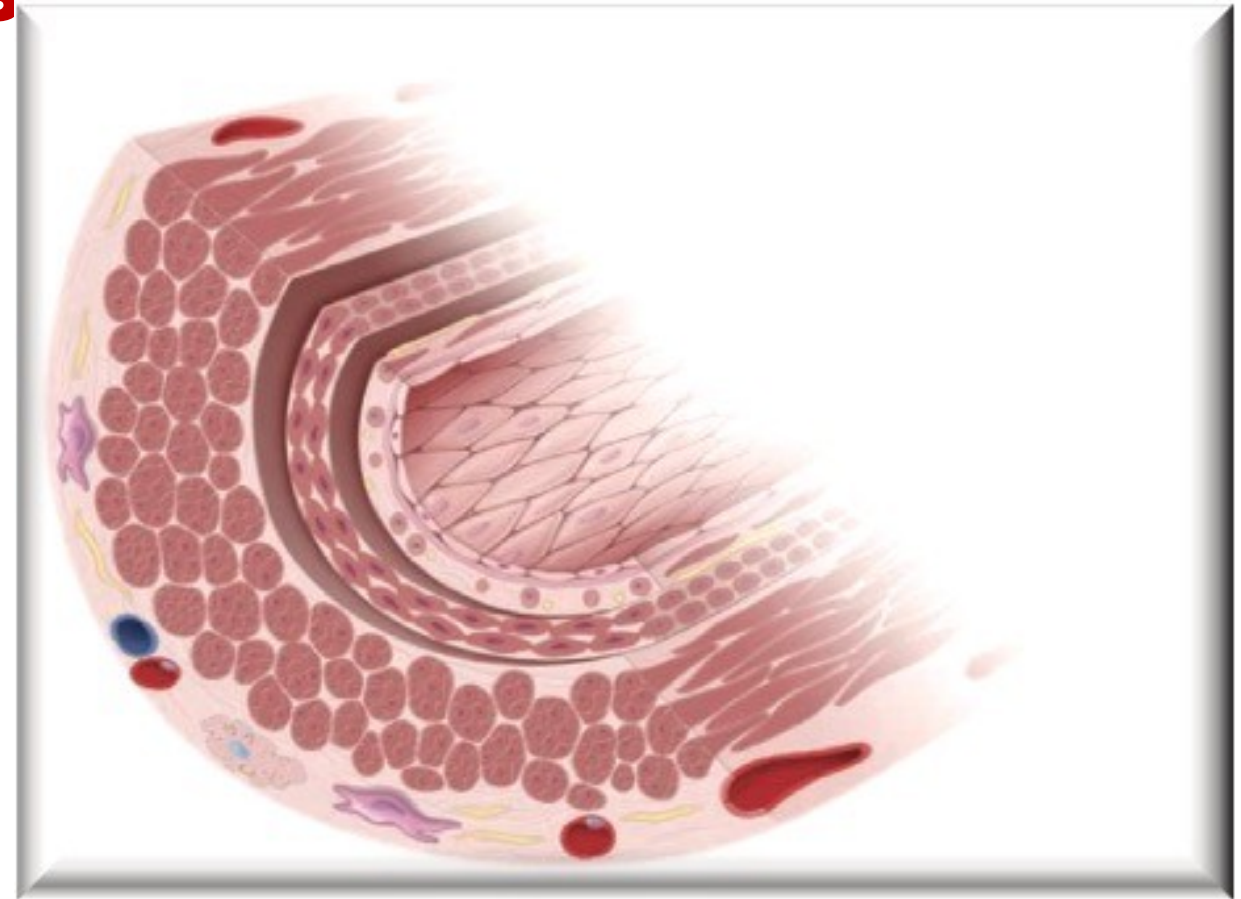
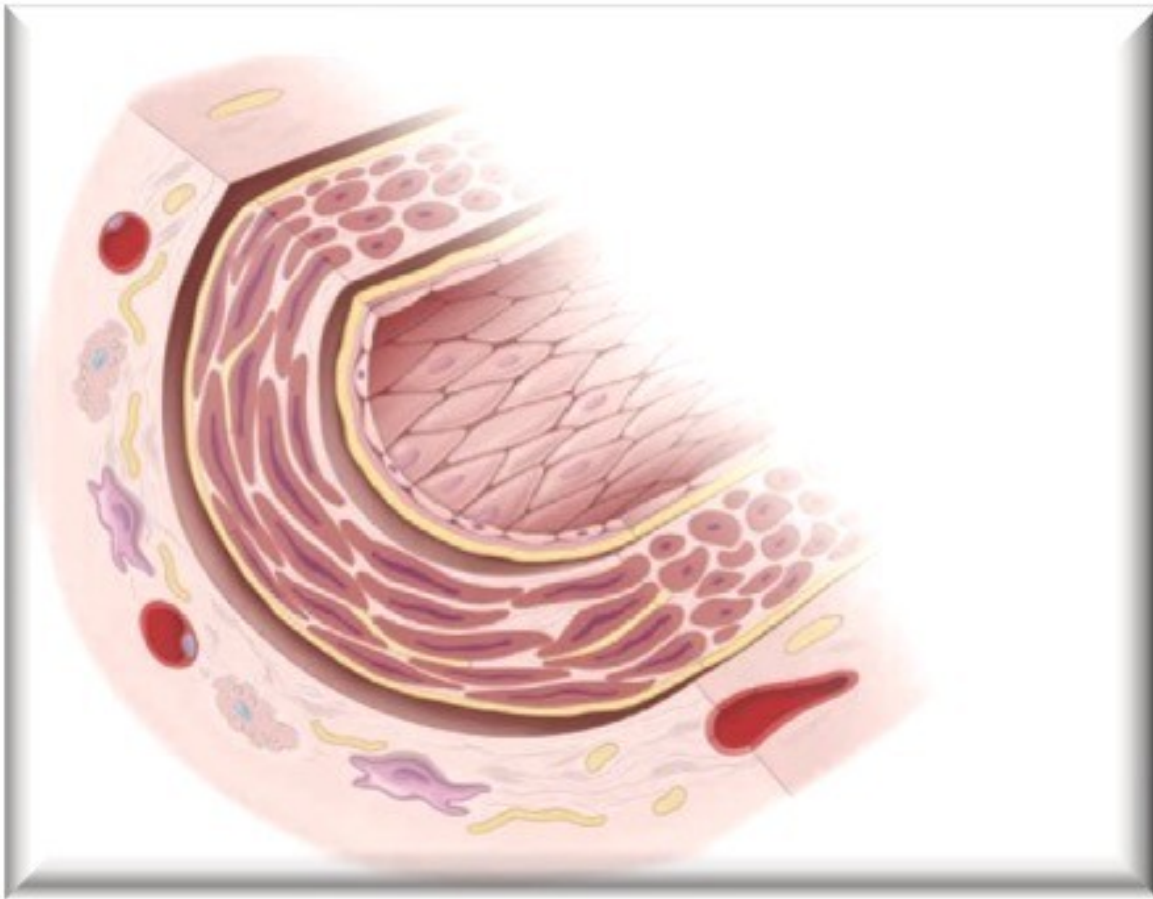


Histology atlas and test: Michael H. Ross and Wojciech Pawlina, 7<sup>th</sup> edition, 2015, pp: 418, 427

# QUIZ



## Identify the type of the following blood vessels



Histology atlas and test: Michael H. Ross and Wojciech Pawlina, 7<sup>th</sup> edition, 2015, pp: 421, 428

# Summary



	Arteries	Veins
<b>General appearance</b>	Thick walls with small lumens; Generally appear rounded	Thin walls with large lumens; Generally appear flattened
<b>Tunica intima</b>	Endothelium usually appears wavy due to constriction of smooth muscle; Internal elastic membrane present in larger vessels	Endothelium appears smooth; Internal elastic membrane absent
<b>Tunica media</b>	Normally the thickest layer in arteries; Smooth muscle cells and elastic fibers predominate (the proportions of these vary with distance from the heart); External elastic membrane present in larger vessels	Normally thinner than the tunica externa; Smooth muscle cells and collagenous fibers predominate; Nervi vascularis and vasa vasorum present; External elastic membrane absent
<b>Tunica adventitia</b>	Normally thinner than the tunica media in all but the largest arteries; Collagenous and elastic	Normally the thickest layer in veins; Collagenous and smooth fibers predominate; Some smooth muscle



# Summary



Type of Artery	Outer Diameter (Approx. Range)	Intima	Media	Adventitia	Roles in Circulatory System
<b>Capillaries</b>	10-4 $\mu\text{m}$	Endothelium only	A few pericytes only	None	Exchange metabolites by diffusion to and from cells
<b>Venules (postcapillary, collecting, and muscular)</b>	10-100 $\mu\text{m}$	Endothelium; no valves	Pericytes and scattered smooth muscle cells	None	Drain capillary beds; site of leukocyte exit from vasculature
<b>Small veins</b>	0.1-1 mm	Endothelium; connective tissue with scattered smooth muscle fibers	Thin, 2-3 loose layers of smooth muscle cells	Connective tissue, thicker than media	Collect blood from venules
<b>Medium veins</b>	1-10 mm	Endothelium; connective tissue, with valves	3-5 more distinct layers of smooth muscle	Thicker than media; longitudinal smooth muscle may be present	Carry blood to larger veins, with no backflow
<b>Large veins</b>	> 10 mm	Endothelium; connective tissue, smooth muscle cells; prominent valves	> 5 layers of smooth muscle, with much collagen	Thickest layer, with bundled longitudinal smooth muscle	Return blood to heart



# Suggested textbooks



**1- Junqueira`s Basic Histology; Text and Atlas. 14<sup>th</sup> edition 2016, pp: 226-229.**

**2- Histology atlas and test: Michael H. Ross and Wojciech Pawlina, 7<sup>th</sup> edition, 2015, pp: 423-427**



**Thank  
You**

*Mahalo*

**Kiitos**

*Tack*

**Grazie**

**Toda**

*Obrigado*

**Thanks**

**Takk**

**Gracias**

**Merci**